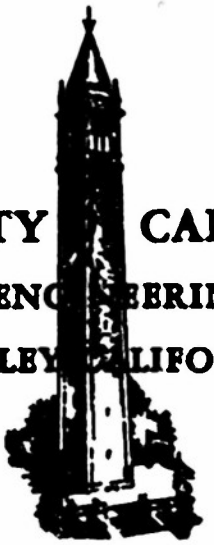

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THE CORRELATION OF HIGH TEMPERATURE RUPTURE DATA FOR NIOBIUM

Twenty Eighth Technical Report

By

Raymond L. Orr and Douglas W. Bainbridge

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Raymond L. Orr[1] and Douglas W. Bainbridge[1]

Twenty Eighth Technical Report, Series 22, Issue 28
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ABSTRACT

Stress-rupture data for niobium were obtained at 1144°K under four stress conditions between 18,000 and 25,000 psi. These data correlated well with existing rupture data for the same material at 1255°K by means of the relation $t_r e^{-\Delta H_r/RT} = f(\sigma)$, where σ is the stress, T is the absolute temperature, R is the gas constant, and ΔH_r is the experimental activation energy for rupture. ΔH_r was found to be equal to 75,000 calories per mole for niobium.

THE CORRELATION OF HIGH TEMPERATURE RUPTURE DATA FCR NIOBIUM

It has recently been shown[1] that stress-rupture data for metals at elevated temperatures are correlatable by means of the equation

$$\theta_r = f(\sigma) \qquad (1)$$

where σ = the applied stress

θ_r = temperature-compensated time at rupture

$= t_r e^{-\Delta H_r/RT}$ for a constant temperature test

t_r = time to rupture

T = temperature of test in absolute degrees

R = gas constant in calories per degree per mole

and ΔH_r = experimental activation energy for rupture in calories per mole.

For a given metal, ΔH_r was found to be a constant equal to the activation energies for high temperature creep and self-diffusion.

The rupture properties of relatively pure niobium in an atmosphere of helium under three stresses at 1255°K have been determined by Grassi, Bainbridge and Harman[2]. Since the same material and apparatus used by those investigators were readily available, it was decided to extend their measurements to include data at some other temperature in order to permit evaluation of the activation energy for rupture of niobium through application of Equation 1.

Rupture data for 99.8 percent niobium have therefore been obtained under four stresses at 1144°K using the same material and equipment described previously by Grassi, Bainbridge and Harman[2,3]. The test specimens, fabricated from 0.125 inch diameter wire with reduced sections 0.08 inch in diameter and 0.5 inch long, were annealed in a helium

atmosphere at 1255°K for two hours prior to testing. The tests were conducted in a protective atmosphere of high purity helium at 3 psig in a sealed chamber heated by a vertical glo-tube furnace, the temperature of which was measured and controlled by means of a chromel-alumel thermocouple. The load was applied to the interior of the chamber through the use of a sylphon bellows.

These data together with the data at 1255°K reported by Grassi, Bainbridge and Harman[2] are presented in Table I. The nominal stress listed is the initial stress for each test.

TABLE I

Stress-Rupture Properties of Niobium

Temperature	Nominal Stress psi	Rupture Time Hours
1255°K	19,200	7.6
	16,900	23.9
	14,500	82.0
1144°K	25,000	3.6
	22,500	27.5
	20,000	79.3
	18,000	242.7

Analysis of these data by means of Equation 1 resulted in the good correlation shown in Figure 1, yielding 75,000 calories per mole as the activation energy, ΔH_r, for the rupture of niobium. It is believed that this value should approximate the value of the activation energy for the high temperature creep and self-diffusion of niobium.

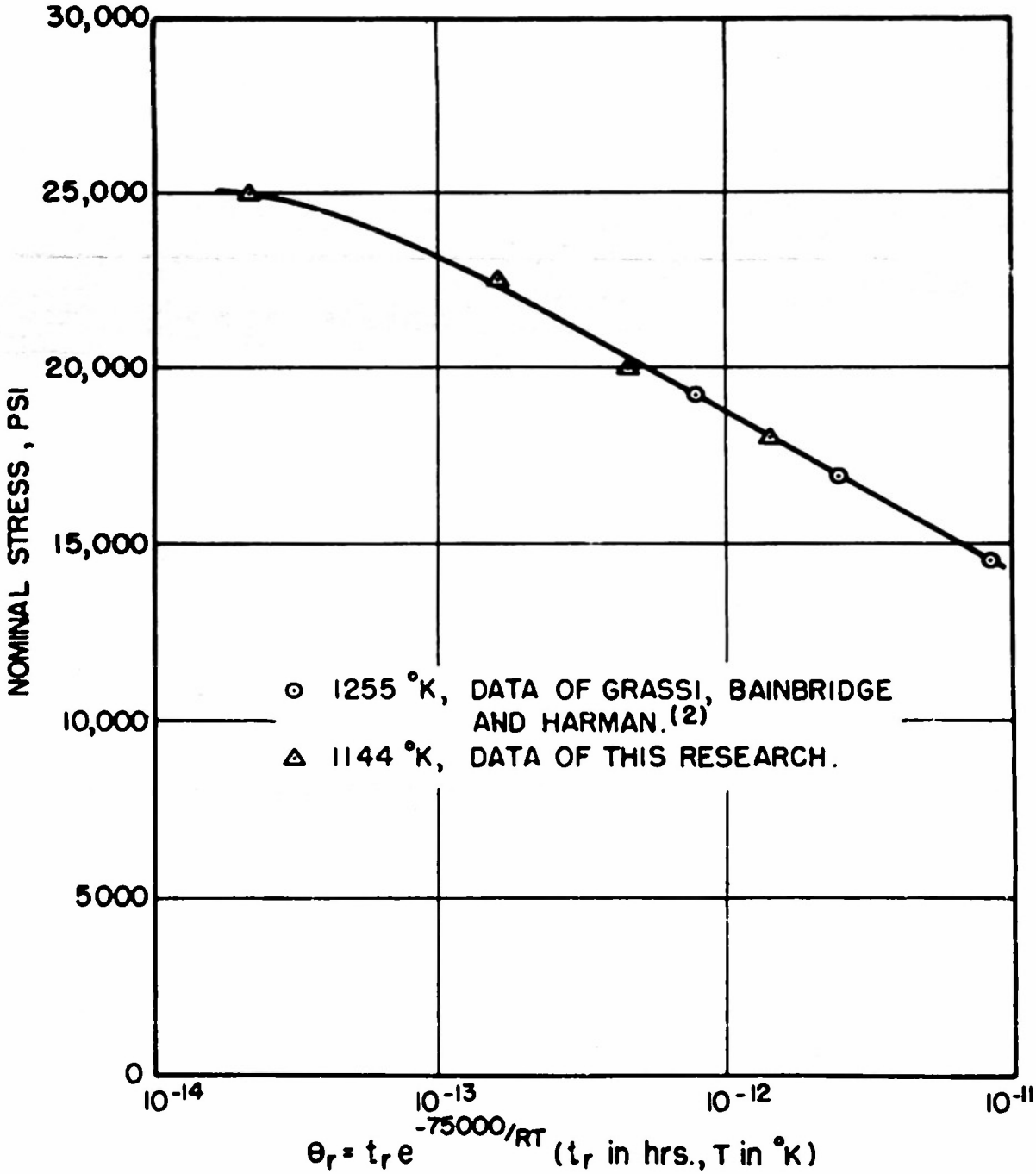

FIG. 1 CORRELATION OF STRESS-RUPTURE DATA FOR 99.8 % NIOBIUM BY MEANS OF THE RELATION $\theta_r = f(\sigma)$.

ACKNOWLEDGMENTS

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In addition appreciation is expressed to Professor J. E. Dorn and to Mr. O. D. Sherby for their interest in and contributions to this study.

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